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Original article

Structure and floristic composition of a piedmont evergreen forest in the central Ecuadorian Amazon, Puyo, Pastaza

Estructura y composición florística de un bosque siempreverde piemontano del centro de la Amazonía ecuatoriana, Puyo, Pastaza

Estrutura e composição florística de uma floresta perene do Piemonte na Amazônia central equatoriana, Puyo, Pastaza

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ABSTRACT

Studies of floristic structure and composition are important for forest management and conservation. The objective of this work was to characterize the structure and floristic composition of a piedmont evergreen forest in the central Ecuadorian Amazon, Puyo River micro-basin, Pastaza. Five permanent transects of 0, 1 ha (10 x 100 m) were established, recording the species with d $_{1.30}$ e" 10 cm. The structure was determined by stratification, sociological position, diameter classes, mixing quotient and the ecological importance value index. 65 species were recorded within 53 genera and 30 families, with a total of 322 individuals. The families with the highest species richness were: Fabaceae (14), Euphorbiaceae (10), Lauraceae (8) and Urticaceae (8) which represented 40, 8 % of the total species and with the highest number of individuals, Arecaceae (101), Euphorbiaceae (58), and Melastomataceae (33), which represented 59.7 % of the total. The predominance of a non-continuous vertical distribution pattern was reported (78 %), determined by the scarce representation of the species in the strata. The distribution of individuals by diameter classes and the mixing ratio reflected a greater concentration in the lower classes, as an indicator of the forest's heterogeneity. The species *Wettinia maynensis*, *Alchornea glandulosa* and *Miconia splendens* were key to this ecosystem, with a higher index of ecological importance. The study suggests that the forest has a modified composition and structure, with the presence of pioneer species typical of the succession, which serves as a reference for the changes experienced by areas of interest for biodiversity.

Keywords: montane forest, micro-basin, vertical structure, horizontal structure

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RESUMEN

Los estudios de estructura y composición florística son importantes para la gestión y conservación forestal. El objetivo de este trabajo fue caracterizar la estructura y composición florística de un bosque siempreverde piemontano del centro de la Amazonía ecuatoriana, microcuenca del río Puyo, Pastaza. Se establecieron cinco transectos permanentes de 0,1 ha (10 x 100 m), registrando las especies con $d_{1.30}$ e" 10 cm. Se determinó la estructura mediante estratificación, posición sociológica, clases

diamétricas, cociente de mezcla y el índice de valor de importancia ecológica. Se registraron 65 especies dentro de 53 géneros y 30 familias, con un total de 322 individuos. Las familias con mayor riqueza de especies fueron: Fabaceae (14), Euphorbiaceae (10), Lauraceae (8) y Urticaceae (8) que representaron el 40,8 % del total de especies y con mayor número de individuos, Arecaceae (101), Euphorbiaceae (58), y Melastomataceae (33), que representaron el 59,7 % del total. Se reportó el predominio de un patrón de distribución vertical no continúo (78 %), determinado por la escasa representación de las especies en los estratos. La distribución de individuos por clases diamétricas y el cociente de mezcla reflejaron mayor concentración en las clases inferiores, como indicador de la heterogeneidad del bosque. Las especies *Wettinia maynensis*, *Alchornea glandulosa* y *Miconia splendens* resultaron claves de este ecosistema, con mayor índice de importancia ecológica. El estudio sugiere que el bosque presenta una composición y estructura modificada, con presencia de especies pioneras típicas de la sucesión, lo cual sirve como referencia de los cambios que experimentan áreas de interés para la biodiversidad.

Palabras clave: bosque montano, microcuenca, estructura vertical, estructura horizontal

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RESUMO

Estudos de estrutura e composição florística são importantes para o manejo e conservação florestal. O objetivo deste trabalho foi caracterizar a estrutura e a composição florística de uma floresta perene do sopé da Amazônia central equatoriana, microbacia do rio Puyo, Pastaza. Foram estabelecidos cinco transectos permanentes de 0,1 ha (10 x 100 m), registrando as espécies com d1,30 e" 10 cm. A estrutura foi determinada pela estratificação, posição sociológica, classes de diâmetro, quociente de mistura e índice de valor. de importância ecológica. Foram registradas 65 espécies distribuídas em 53 gêneros e 30 famílias, totalizando 322 indivíduos. As famílias com maior riqueza de espécies foram: Fabaceae (14), Euphorbiaceae (10), Lauraceae (8) e Urticaceae (8) que representaram 40,8 % do total de espécies e com maior número de indivíduos, Arecaceae (101), Euphorbiaceae (58) e Melastomataceae (33), que representaram 59,7% do total. A predominância de um padrão de distribuição vertical não contínuo (78%), determinada pela escassa representatividade das espécies nos estratos. A distribuição dos indivíduos por classes o diâmetro e a proporção de mistura

refletiram maior concentração nas classes mais baixas, como um indicador da heterogeneidade da floresta. As espécies *Wettinia maynensis*, *Alchornea glandulosa* e *Miconia splendens* foram fundamentais para este ecossistema, com o maior índice de importância ecológica. O estudo sugere que a floresta apresenta composição e estrutura modificadas, com presença de espécies pioneiras típicas da sucessão, o que serve de referência para as mudanças sofridas por áreas de interesse para a biodiversidade.

Palavras-chave: floresta montanhosa, microbacia, estrutura vertical, estrutura horizontal

INTRODUCTION

The tropical forests located in the Amazon basin are areas of great relevance due to its biological diversity, especially with regard to plant species richness (Noroozi *et al.*, 2018; Guevara *et al.*, 2019; Raven *et al.*, 2020). The Amazon asin brings together 50 % of the world's forests and plays a strategic role in carbon sequestration (Lathuilliere *et al.*, 2016). The Amazon region, with approximately 82,120 km^{2,} represents about 30 % of the national territory of Ecuador and in the regional context 2 % of the Amazon basin. It includes both the flood plains of the rivers of Andean and Amazonian origin, their interfluves, as well as the Amazon Mountain ranges that rise to the south (MAE, 2013). This region is home to sites that contain outstanding floristic resources and the distribution of species is heterogeneous in correspondence with the edaphic and environmental characteristic, which determines differences in terms of floristic composition, diversity and structure of the forests (Maldonado *et al.*, 2018).

Montane forests contain an excellent biological diversity, especially in terms of flora (Aguirre-Mendoza *et al.*, 2018). These forests are of global importance as reservoirs of biodiversity and for their exceptional functions in regulating water flow and maintaining water quality. They are considered a megadiverse site as they are part of the *Uplands Western Amazonia hotspot* (Myers *et al.*, 2000).

The Puyo River micro-basin, in the Ecuadorian Amazon, it is recognized for its multiple social, environmental and economic benefits. The importance of this area is given by its hydroregulatory functions, biodiversity, food provision, protection of the nutrient cycle, carbon retention, pest regulation and pollination, constituting an important part of the economic sustenance of the indigenous populations in the area (García-Quintana *et al*., 2021). However, anthropic pressure due to the unsustainable use of forest resources has caused changes in land use, deforestation and landscape fragmentation, which put the biodiversity, functionality and ecological integrity of these ecosystems at risk, further encouraged by insufficient planning by public institutions for the conservation and protection of these ecosystems.

Studies on vegetation and structure help to understand the dynamics of ecosystems (Mieles-Giler *et al*., 2024; Seidl & Turner, 2022). The information on the structure and floristic composition is an important tool for the assessment of the potential of a forest and the definition of management and conservation strategies (Mena *et al*., 2020).

The objective of this work was to characterize the structure and floristic composition of a piedmont evergreen forest in the central Ecuadorian Amazon, Puyo River micro-basin, Pastaza.

MATERIALS AND METHODS

Area of study

The study included an area of a Piedmont evergreen forest, located in the micro-basin of the Puyo River, within the hydrographic demarcation of the Pastaza River, in the Mera canton, Pastaza province, within the buffer zone of the Llanganates National Park. It is bordered to the north by the Santa Clara canton, to the south by the Shell parish, to the east by Fátima and Teniente Hugo Ortiz and to the west by the Llanganates National Park (Figure 1). The predominant bioclimatic conditions of the study area correspond to a humid megathermal tropical climate, with an average annual temperature of 21.3 °C and an annual rainfall of 4 119 mm. The lowest rainfall occurs from January to April,

while the highest occurs from May to July. Relative humidity is 84 % and the average altitude is 1 100 m above. sea. level (INAMHI, 2014).

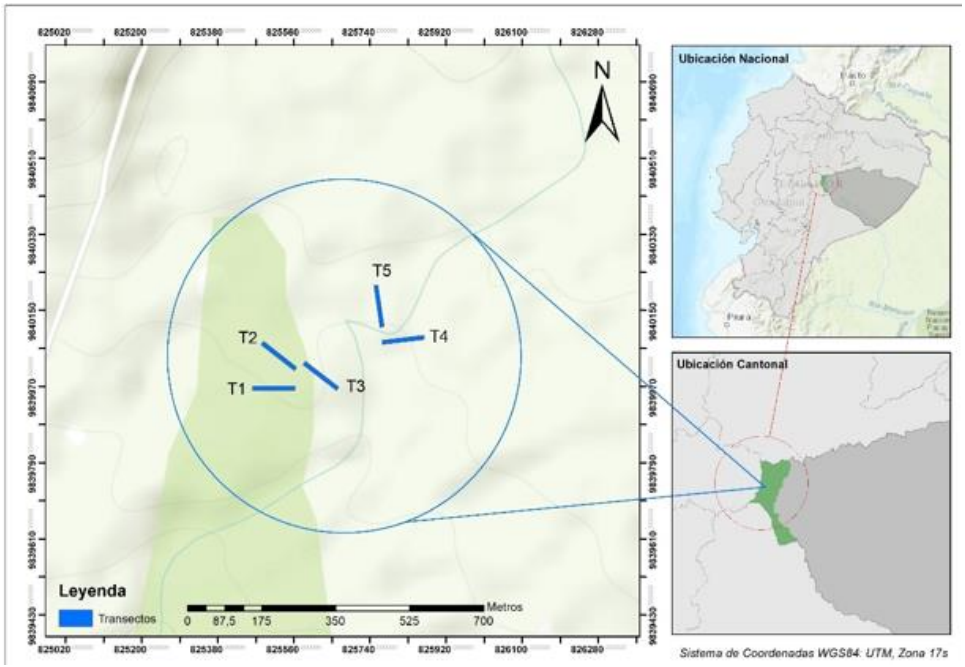

Figure 1. *Geographic - location of the study area corresponding to a piedmont evergreen forest of the Puyo River micro-basin, Pastaza, Ecuador*

Floristic inventory

0.1 ha (10 x 100 m) were established, using random sampling, considering accessibility and topography. The sample size was selected based on the adaptation of the Rapid Inventory transect model proposed by Gentry (1982) and the methodology of Lozano *et al. (2013). All* trees with $D_{1.30} \geq 10$ cm were recorded, which were identified in the field with the support of a botanist expert in Amazonian flora and was confirmed with the Book of Trees of Ecuador (Palacios, 2016) and the collection of samples from the Ecuadorian Amazonian Herbarium (ECUAMZ) of the Amazonian State University.

Structural parameters

With the diameter and height data of the inventoried trees were determined as structural parameters the stratum classes, sociological position, distribution of diameter classes, mixing quotient and importance value index.

The stratification of the forest was analyzed from the conformation of three kinds of strata, according to the criteria of Godínez and López (2006), where the lower stratum (h d" 10 m), middle stratum (10, 1 m h) and the upper stratum (10, 1 m £h) £were considered. 20 m) and the upper stratum (h > 20 m).

The sociological position of each tree species was determined, using the Finol methodology (1976). A phytosociological value was assigned to each substratum and with this the absolute value of the sociological position of the species was calculated, through the sum of the phytosociological values in each substratum by the product of the phytosociological value of the stratum, considered by the number of individuals of the species in that same stratum. Finally, the relative sociological position of each species was obtained. from the following expressions: 1, 2 y 3.

$$VF = \frac{n}{N} \text{ (1)}$$

$$PS_a = VF_i * n_i + VF_m * n_m + VF_s * n_s \text{ (2)}$$

$$PS_r = \frac{PS_a}{PS_t} * 100 \text{ (3)}$$

Where:

VF : Phytosociological value

n : Number of individuals

N : Total number of individuals of all species

PS_a: Absolute sociological position

VF_i: Phytosociological value of the lower sub-stratum

VF_m: Phytosociological value of the middle sub-stratum

VF_s: Phytosociological value of the upper sub-stratum

n_i: Number of individuals in the lower sub-stratum

n_m: Number of individuals in the middle substratum

n_s= number of individuals in the upper sub-stratum

PS_r: Relative sociological position

PS_t: total sociological position

The diameter distribution was carried out from the formation of diameter classes (CD), which were grouped in intervals of 10 cm, with the lowest class being 10-20 cm and the highest being greater than 80 cm. The number of intervals and the width of the class were obtained from that described by Melo & Vargas (2003).

The mixing quotient was determined to express the homogeneity or heterogeneity of the floristic composition. It was obtained by applying the formula proposed by Lamprecht (1990) Equation 4:

$$CM = \frac{N}{S} \quad (4)$$

Where:

N : Number of individuals

S : Number of species

The ecological importance value index of each species was determined by applying the formula described by Bascopé & Jorgensen (2005) and Aguirre (2013) Equation 5:

$$IVI = AR + DR + FR \quad (5)$$

Where:

AR: Relative abundance

DR: Relative dominance

FR: Relative frequency

Statistical processing

A principal component analysis was performed using the CANOCO ver.5.0 program, from the species data matrix and the transects, with the purpose of determining the contribution of the abundance of the species in each of the study transects.

RESULTS

Floristic composition of the evergreen Piedmont forest of the Puyo River micro-basin, Pastaza

were recorded within 53 genera and 30 families, with a total of 322 individuals. A high diversity of botanical families was reported, but with a disproportionate composition in terms of the number of individuals and species. The families with the greatest species richness do not correspond to those with the greatest number of individuals, resulting in Fabaceae with the greatest number of species (14) and Arecaceae with the greatest number of individuals (101). The families with the greatest number of species represented 40.8% of the total species and those with the greatest number of individuals represented 59.7% of the total. The high representativeness of the Arecaceae family is given by the presence of the *Wettinia maynensis species*, which indicated the abundance of this palm as the predominant ecological group in the upper area of the Puyo River micro-basin at an altitude between 1 122 and 1 292 m s. n. m. On the other hand, 14 families, corresponding to 46,66 % of the total, were represented by one species and one individual (Figure 2).

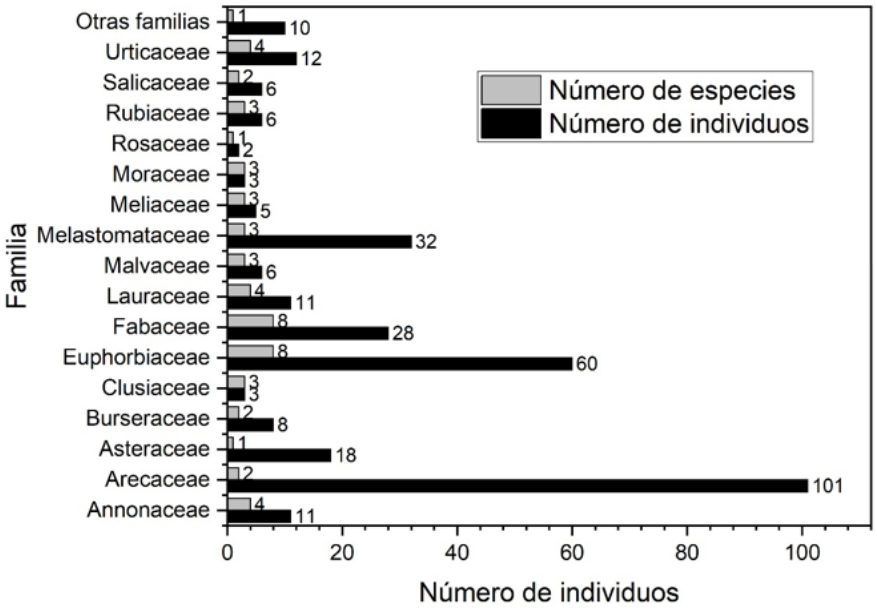

Figure 2. - *Abundance - of species and individuals by botanical families in the Piedmont evergreen forest of the Puyo River micro-basin*

Forest stratification

The vertical stratification of the Piedmont evergreen forest reported that the middle stratum, which includes the height class of 10.1 to 20 m, was the most represented with a total of 225 individuals and the upper stratum , with a height class greater than 20 m , was the least represented with 7 individuals , whose canopy reached up to 30 m in height (Figure 3).

Three species were identified as the most representative of the upper stratum *Dacryodes olivifera, Alchornea glandulosa* and *Inga velutina* , which are considered dominant and six species in the lower stratum *Inga velutina, Miconia splendens, Tovomitopsis membranacea, Trichilia pallida, Sterculia colombiana, Wettinia maynensis, Alchornea glandulosa* , which correspond to the dominated ones .

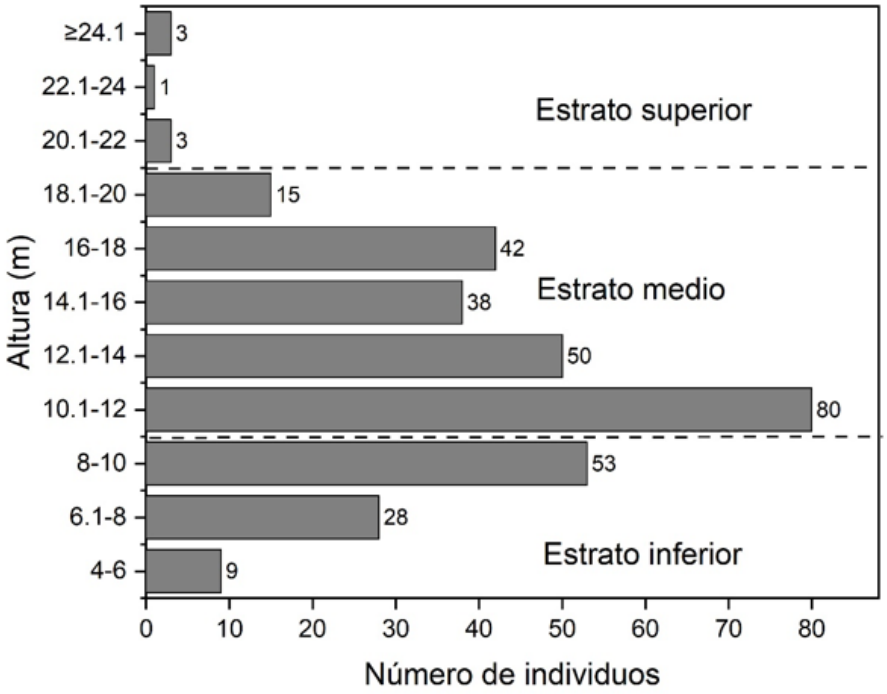

Figure 3. *- Abundance of individuals by class of altura enthe Piedmont evergreen forest of the Puyo River micro-basin*

Sociological position

Of the ten species with the highest sociological position, *Wettinia maynensis, Alchornea glandulosa, Miconia splendens* and *Inga velutina* presented the highest values (Table 1). It is noteworthy to highlight that not all species were found represented in the three strata of the forest. Of the total number of inventoried species, 78.0 % were found present in only one stratum (middle stratum), 17.0 % were shared by the lower and intermediate stratum and only 5.0 % of the species were present in the three strata, with a continuous vertical distribution. The species that presented the highest continuous distribution were: *Alchornea glandulosa* , *Inga velutina* and *Dacryodes olivifera* . The low presence of species in the three strata reflected the predominance of a non-continuous vertical distribution pattern, which puts the permanence of the species in the study plots at risk.

Table 1. *- Absolute and relative phytosociological position of the ten species with the highest value in the strata of the Piedmont evergreen forest of the Puyo River micro-basin*

Species	PS_a	PS_r
Alchornea glandulosa Poepp	30, 36	15.83
Wettinia maynensis Spruce	51.92	27.07
Miconia splendens (Sw) Griseb	10.39	5.42
Inga velutina Willd	7.67	4.00
Sage (L) Morong	4.25	2.21
Cecropia ficifolia Warb. ex. Snethl	3.54	1.84
Ocotea cernua Ness (Mez)	3.54	1.84
Tall happiness Pop	3.54	1.84
Inga multinervis TDPenn	3.10	1.61
Duguetia spiciana March	2.83	1.47

Diametric classes

The diameter class structure was characterized by the highest concentration of individuals in the lower diameter classes, which resembled the typical shape of an inverted "J". The highest percentage of individuals (66 %) was concentrated in the first

diameter class (10-20 cm) with a total of 212 trees in 0.5 ha and the lowest percentage in the highest diameter class (> 80 cm) with 1 tree in 0.5 ha (Figure 4).

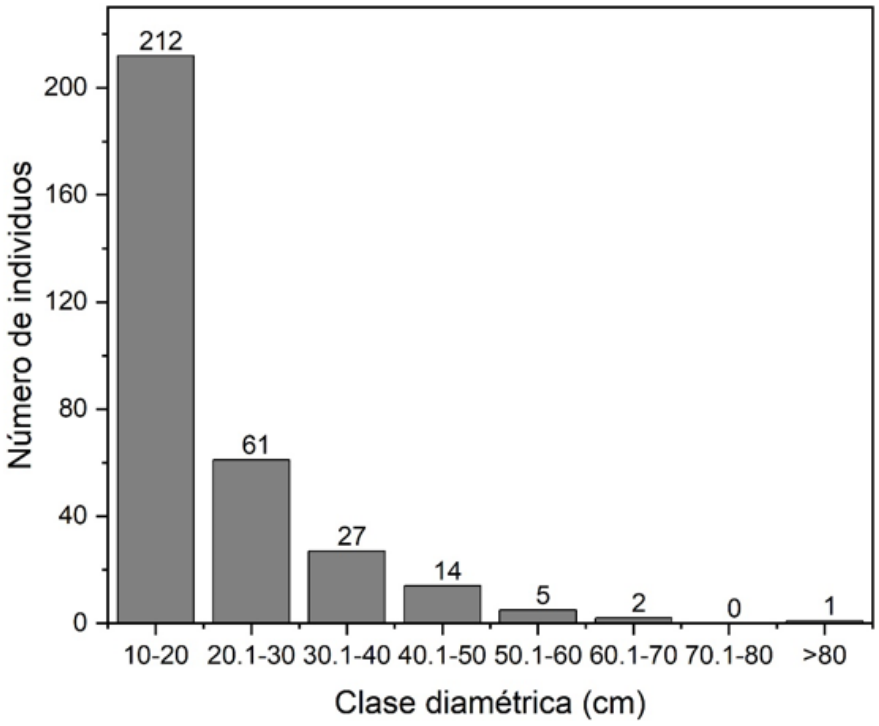

Figure 4. - *Distribution of diameter classes of the tree component in the Piedmont evergreen forest of the Puyo River micro-basin*

Mixing ratio

The mixing ratio, by diameter classes, resulted with a higher proportion for the lower class (10-20 cm), which indicated that for every five individuals it is possible to find a different species. In the higher classes this proportion was lower and indicated greater heterogeneity (Table 2).

Table 2. - *Mixture quotient for each of the diameter classes of the Piedmont evergreen forest*

C D (cm)	Number of species	Number of individuals	Mixing ratio
10-20	45	212	1:5
20,1-30	26	61	1:2
30,1-40	9	27	1:3
40,1-50	8	14	1:2
50,1-60	3	5	1:2
60,1-70	2	2	1:1
70,1-80	0	0	1:0
>80	1	1	1:1

Value of ecological importance

The ecological weight of the species with $D_{1.30}$ >10 cm resulted in different values and reflected that the most dominant species were the least abundant and frequent. Among the ten species with the greatest ecological weight, which represented 15, 15 % of the total, *Wettinia maynensis* , *Alchornea glandulosa* and *Miconia splendens* occupied the first three positions due to their high frequency and, fundamentally, their high abundance, accumulating together 28% % of the importance value. The rest of the species that scored up to the tenth ecological position presented similar values between them. On the other hand, the ecological position occupied by *Piptocoma discolor,* a pioneer species of secondary forest, typical of ecological succession, was worrying. This reflects the changes that this important area of interest for biodiversity is experiencing (Table 3).

Table 3. *Ecological - importance value index of the ten most valuable species in the Piedmont evergreen forest of the Puyo River micro-basin*

Species	**AR**	**FR**	**DR**	**IVI**
Wettinia maynensis Spruce	29, 42	4, 42	12, 80	15, 55
Alchornea glandulosa Poepp	15, 01	4, 42	20,29	13,24
Miconia splendens (Sw) Griseb	5,70	3,53	2,78	4,00
Piptocoma discolor (Kunth) Pruski	5,40	2,65	11,17	6,41
Inga velutina Willd	4, 20	2, 53	4, 97	3, 90
Dacryodes olive Cuatrec	2, 10	3, 53	4, 35	3.33
Ficus paraensis Miq	0, 3 0	0, 88	4, 69	1, 96
Sage (L) Morong	1, 80	3, 53	1, 87	2, 40
Inga multinerved TDPenn	1, 50	3, 53	1, 11	2, 05
Ocotea cernua Ness (Mez)	1, 50	2, 65	1, 72	1, 96

Principal component analysis

The principal component analysis (PCA) resulted in eigenvalues of 0.36 and 0.27 for the first two axes, which allowed the interpretation of the relationship between the species according to their coincidence in the sampling units. Between the first two axes, 64% was explained. % of the total variance explained and only the first component 36 % of data variability.

The ordination diagram (Figure 5) described the position of the transects and the species with respect to each axis, finding that the positively correlated species were grouped on the same axis and the negatively correlated ones were placed on the opposite side, which determines the existence of a differential pattern in relation to the abundance of species. On axis 1 of the positive end was located the transect T5 and on the negative end T4, which showed a high abundance of species (Inga *velutina, Inga multinervis, Dacryodes olivifera , Wettinia maynensis*) . On axis 2 of the positive end were located T1 and T2 , observing that the length of the vector is different between them , which is due to the greater abundance of species in T 1, where *Piptocoma discolor* predominates . and *Ficus paraensis* , this area being negatively correlated with T 4 and T 5 ; at the negative end of

this axis was T3, represented by the low abundance of species , making it one of the most vulnerable areas from an ecological point of view.

On the other hand, it was found that only in transects T5, T4 and T1 the presence of rare species was reported such as: *Cordia panamensis, Duguetia hadrantha, Guarea kunthian , Guarea purusana, Endlicheria serícea, Eschweilera caudiculata, Hieronyma alchorneoides, Isertia laevis, Matisia longiflora* and *Maytenus macrocarpaen* , which also contribute to the species richness (Figura 5).

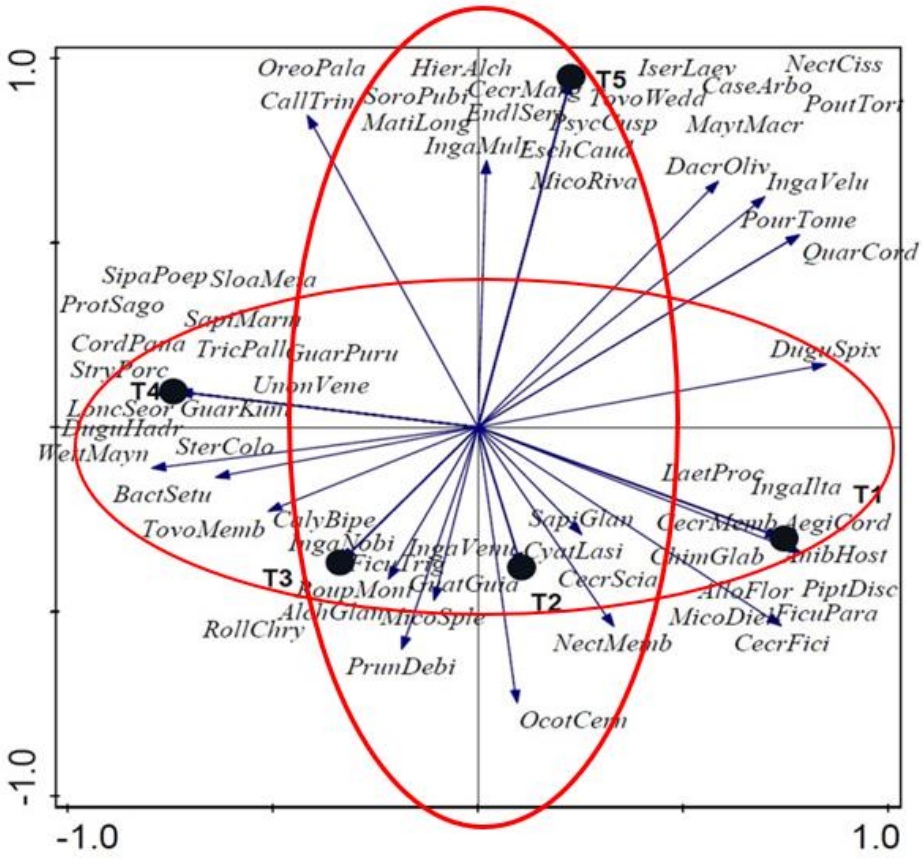

Figure 5. *- Spatial arrangement of transects based on species abundance in the Piedmont evergreen forest*

Legend: *Laetia procera (LaetProc); Inga ilta (IngaIlta); Sapium glandulosum (SapiGlan); Cecropia membranácea (CecrMemb); Aegiphila cordata (AegyCord); Cyathea lasiosora (CyatLasi); Chimarrhis glabriflora (ChimGlab); Aniba hostmanniana (AnibHost); Cecropia sciadophylla (CecrScia); Allophylus floribundus (AlloFlor); Piptocoma discolor (PiptDisc); Miconia dielsii (MicoDiel); Ficus paraensis (FicuPara); Cecropia ficifolia (CecrFici); Nectandra membranacea (NectMemb); Ocotea cernua (OcotCern); Bactris setulosa (BactSetu);*

Tovomitopsis membranacea (TovoMemb); Calyptranthes bipennis (CalyBipe); Inga nobilis (IngaNobi); Inga venusta (IngaVenu); Ficus trigona (FicuTrig); Guatteria guianensis (GuatGuia); Roupala montana (RoupMont); Alchornea glandulosa (AlchGlan); Miconia splendens (MicoSple); Rollinia chrysocarpa (RollChry); Prunus debilis (PrunDebi); Siparuna poeppigii (SipaPoep); Sloanea meianthera (SloaMeia); Protium sagotianum (ProtSago); Sapium marmieri (SapiMarm); Cordia panamensis (CordPana); Trichilia pallida (TricPall); Guarea purusana (GuarPuru); Stryphnodendron porcatum (StryPorc); Unonopsis veneficiorum (UnonVene); Lonchocarpus seorsus (LoncSeor); Guarea kunthiana (GuarKunt); Duguetia hadrantha (DuguHadr); Wettinia maynensis (WettMayn); Sterculia colombiana (SterColo); Oreopanax palamophyllus (OreoPala); Calliandra trinervia (CallTrin); Hieronyma alchorneoides (HierAlch); Left insertion (IserLaev); Nectandra cissiflora (NectCiss) ; Sorocea pubivena (SoroPubi); Cecropia marginalis (CerMa) ; Tovomita weddelliana (TovoWeda); Tree cheese (CaseArbo); Pouteria Torta (PoutTort); Matisia longiflora (MatiLong); Endlicheria sericea (EndlSer); Psychotria cuspidulata (PsyCusp); Maytenus macrocarpa (MaytMarc); Inga multinervis (IngaMult); Eschweilera caudiculata (EschCaud) ; Rival Miconia (MicoRiva); Dacryodes olivifera (DacrOliv); Inga velutina (IngaVelu); Pourouma tomentosa (PourTome); Quararibea cordata (QuarCord) ; Duguetia spixiana (DuguSpix).

DISCUSSION

Floristic composition

The floristic composition of the Piedmont evergreen forest of the Puyo River micro-basin, in the center of the Ecuadorian Amazon (65 species, 53 genera and 30 botanical families) was higher than that reported by Maldonado *et al*. (2018) in a low montane forest, in the El Suhi micro-basin, Palanda canton, Zamora Chinchipe province, in the southeast of Ecuador and the study carried out by Aguirre *et al*. (2021a) in a montane forest in the Santiago parish in Loja , Ecuador , which recorded 47 tree species . It was also lower than the study carried out in Huashapamba, Loja, Ecuador. which recorded 54 species, 39 genera and 27 families (Aguirre *et al*., 2021b) and different from what was reported by Aguirre *et al*., (2017) in a permanent plot of a hectare in the Loja basin, which reported 45 species, 39 genera and 29 families.

The wealth recorded for the Arecaceae family was similar to that reported by Patiño *et al*. (2015) in a Piedmont evergreen forest at 600 to 700 masl in the Piatúa River basin, Napo, Ecuador and contrastable with the abundance of other families such as Euphorbiaceae and Melastomatacea.

Vertical and horizontal structure

The disproportionate distribution in terms of the number of individuals and species corresponds to the criteria of Alvis (2009) and Ter Steege *et al.* (2013) where they refer that in this type of ecosystem one of the fundamental characteristics is the large number of species represented by few individuals and complex spatial patterns.

The vertical distribution of individuals in the Piedmont evergreen forest, with predominance of trees in the middle stratum, it coincides with what was reported by Blaser and Camacho (1991), who refer that a typical characteristic of evergreen forests is to have greater species richness and high density of individuals in the middle and lower strata. These results are similar to those reported by Aguirre *et al*. (2024) who indicated that there are more individuals in the middle stratum, representing 78.94 % of the heights. This differs from those recorded by Aguirre *et al*. (2022) in a low montane evergreen forest in an altitudinal gradient in San Francisco del Vergel, Palanda, Zamora, Chinchipe, Ecuador. These differences could be related to varying degrees of disturbance and differences in ecological conditions between the sites studied, which affects the vertical distribution of individuals.

The scarce presence of species recorded in the high canopy (7 trees), which corresponds to the upper stratum of the Piedmont evergreen forest, is due to the fact that processes such as mortality and species recruitment are very dynamic in tropical humid forests (Lamprecht, 1990).

The behavioral pattern described in the sociological position of the species in this study agrees with the results obtained in the characterization of a forest in the central west of the province of Chaco, Argentina (Michela, 2016). This author reported an uneven distribution of the presence of species in the three strata, indicating that those that had a more uniform distribution in the vertical structure ensure their place in the structure and composition of the forest formation. This corresponds to what Finol (1976) stated, who

indicated that the more regular the distribution of individuals of a species in the vertical structure of a forest, the greater its value in the relative sociological position.

The low presence of species in the three forest strata indicated that the predominance of a vertical distribution pattern was not continuous. This behavior reflects that Most species are sociologically in decline and have low reproductive potential, which gives them a character of vulnerability in the face of different environmental events that are very favorable in the upper area of the Puyo River micro-basin. such as: landslides, strong winds, changes in land use and deforestation. This could limit the stability and permanence of the species in the study area, an aspect that has been described by Louman et *al*. (2001), which is due to the ecological demands of each of the species and the ability to compete with others for the availability of resources.

The diameter structure of the Piedmont evergreen forest adopted the shape of an inverted "J", which is a common feature found in tropical forests, which has been reported by Lozano *et al*. (2009) and Aguirre *et al*. (2017, 2018). This behavior highlights the heterogeneity of the forest, composed of trees of different ages (García-Cox *et al*., 2023).

inverted "J" shaped trend indicated that the forest community is developing towards more advanced stages of growth and productivity (Lamprecht, 1990), where young individuals are replacing specimens that are in the senile phase. This trend is similar to the o previously obtained in an analysis of the structure of the species of a Piedmont evergreen forest in the province of Napo (García *et al*., 2021). These authors determined that the largest number of individuals were grouped in the diameter class of 0 to 10 cm, with a representativeness of 86.6 %.

The results obtained in the mixing ratio , as an indicator of the horizontal structure, correspond to Lamprecht (1990), who points out that in Amazonian forests it varies in a proportion of 1:3 to 1:4 and in average conditions it is approximately 1:7. This author reported in a tropical forest in Colombia, a ratio of 1:7 as an approximate mixing ratio for a forest area with environmental conditions similar to the present investigation .

The most ecologically important species, according to the results of the IVI were: *Wettinia maynensis*, *Alchornea glandulosa* and *Miconia splendens.* These results differ from those of Patiño *et al*. (2015) who recorded as species of greater ecological importance in a Piedmont evergreen forest in the Piatúa River, Napo, Ecuador, in a range of 600 - 700 m above sea level *Irealtea delt or idea, Nectandra sp* . and *Ocotea aciphylla* . It is also different from that reported by Maldonado *et al*. (2018) in a low montane evergreen forest in Palanda, Zamora Chinchipe, Ecuador, who reported Alsophila *cuspidata, Nectandra lineatifolia and Nectandra* sp . as species of greater ecological importance. These differences could be due to the altitudinal degree between the study sites.

CONCLUSIONS

The Piedmont evergreen forest of the upper area of the Puyo River micro-basin has a high richness of species, where the Arecaceae family stands out with 101 individuals.

The relative sociological position of the species described the predominance of a non-continuous vertical distribution pattern, the 78 % of the species were represented in a single stratum, so the que lamajority of the species are in decline and with low reproductive potential.

The structural patterns of the Piedmont evergreen forest reflected the existence of a heterogeneous ecosystem with trees 10-20 m tall, and a higher concentration of individuals in the lower diameter classes, which reflected the existence of dystaneous trees as a response to an advanced ecological succession process.

The species of greatest ecological importance were: *Wettinia maynensis, Alchornea glandulosa, Piptocoma discolor, Miconia splendens* and *Inga velutina*, so they can be considered key species of this ecosystem. The favorable position of *Piptocoma discolor,* identified as pioneer species of secondary forest, served as a reference for the changes in the horizontal structure experienced by these areas.

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The authors declare not to have any interest conflicts.

***Contribution of the authors*:**

The authors have participated in the writing of the work and analysis of the documents.